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RESEARCH PAPER

Environmental Impact Assessment of Tourism Development on Lut Desert using DPSIR and TOPSIS Models

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Abstract

Tourism is known to be one of the most diverse economic activities in the world. Desert ecosystems are now considered as one of the important natural tourist attractions owing to their unique ecological potential and socio-economic capabilities and values, attractions, and unique features. Lut desert has also attracted a great deal of attention as a tourist destination. This is while t tourism development in the Lut desert cannot be easy due to its natural fragility. Therefore, the current research aimed to prioritize the impacts of tourism development in the Lut desert by integrating the driver-pressure-state-impact-response (DPSIR) model and TOPSIS technique in order to formulate management strategies. DPSIR model was used to analyze different aspects of tourism impacts in terms of five components via a conceptual framework. The values of severity and importance of each of the identified impacts were prioritized using the TOPSIS technique and according to experts' opinions. The results showed that the decline in culture and customs (0.80) and the indicators of cultural and social dichotomy (0.31) were the most important impacts. Land use changes for the sake of infrastructural development (0.27) and activation the government diplomacy (0.26) were found to be the next most important priorities. Tourism development in the Lut desert has positive and negative impacts; therefore, in order to develop tourism with minimal damages to the nature (ecotourism), it is necessary for the planners and managers to consider the relevant policies. Finally, this article proposed strategies conducive to accurate and wise development of tourism, such as codified educational programs to the tourist and host community, planning, and appropriate land use management for infrastructural development.

Keywords: Tourism development, EIA, Responses, DPSIR, Lut desert, TOPSIS

Introduction

Tourism is one of the most diverse economic activities in the world. In many countries, it is considered as the most important source of income and job creation, and the main motivation for infrastructural development and provision of facilities. However, the rapid growth of tourism industry and the increase in the number of tourists around the world are serious threats to the wildlife and environmental protection (Goodwin, 1996). Over the recent years, the growth and development of sustainable tourism, with an emphasis on controlling its environmental impacts, have been considered to replace the mass tourism, whose objective is to preserve the natural and traditional values of local communities in tourist sites. This new and sustainable type of tourism, which supports and preserves the natural environment, is called ecotourism (Chiu, Lee, and Chen, 2014; Gigović, Pamučar, Lukić, and Marković, 2016). Ecotourism

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creates positive relationships between tourism, biodiversity, and local people through the appropriate tourism management strategies (Ross and Wall, 1999). The sustainable development strategy is defined based on five principles: striving to preserve the environment, encouraging the participation of local communities, empowering volunteer groups, obtaining economic benefits and preserve local cultures. Tourism takes place in a geographical context consisting of natural and cultural-social environments (Cobbinah, 2015). Both environments are composed of a number of factors that affect tourism, which are themselves affected by it. Tourism can also have different and significant impacts on the tourist destinations. These impacts could be social, cultural, economic, political, and environmental. Due to the complexity and scope of tourism activities, the associated impacts also have several interrelated dimensions that should be considered when investigating tourism impact (Mason, 2003). Where tourism develops without planning, policy-making, or considering the social, cultural, and economic characteristics, it often struggles with social and biological problems. Such an approach to the development of (eco) tourism causes social and environmental damages difficult to compensate for. Thus, instead of creating a source of income, these areas turn into serious crisis for both people and managers (Tavakkoli-nia, Matkan, Sarrafi, and Borbori, 2018). Given the sensitivity of the issue, the importance of proper planning, and prevention of probable problems in prospective sites of ecotourism development, appropriate scientific methods and models could be highly beneficial and assist the planners and managers in the sustainable tourism development.

Environmental impact assessment is formed with two separate processes; primarily, it systematically analyzes the beneficial and harmful impacts of various development achievements, the purpose of which is to understand the significant impacts of development. Secondly, the environmental impact assessment process paves the way for the creation of appropriate discourse about the project and the impacts of social stockholders and people (Canter and Wood, 1996; Barker and Wood, 1999). The investigation, analysis, and evaluation of planned activities to ensure environmental health and sustainable development in each region is called Environmental Impact Assessment (EIA) (Perdicoúlis and Glasson, 2006), which includes analysis and selection of the appropriate options that are aimed at avoiding costly mistakes in development planning (Lawrexnce, 2013). When human beings interact with the environment, a socio-ecological system (SES) is formed. In fact, this system has a complex relationship with one or more social systems and is influenced by them (Anderies, Janssen, and Ostrom, 2004). Because of the strong interactions between humans and the environment in ecotourism, it could be said that tourism and, consequently, ecotourism are subsumed under the category of SES. Powerful environmental assessment tools and frameworks are then required to track the existing and progressive problems and allow adaptive management (De Jonge *et al*., 2012). One of the most common socio-ecological frameworks is the driver, pressure, state, impact, and response (DPSIR) approach. This approach is a valuable tool enabling the assessment of socio-economic and environmental parameters. This framework has been also proved to be practical for investigating a number of different issues (Bidone and Lacerda, 2004; Caeiro *et al*., 2004; Karageorgis *et al*., 2006); in some issues, it has been integrated with other methods in order to improve the efficacy (Pacheco, Carrasco, Vila-Concejo, Ferreira, and Dias, 2007; Maxim and Spangenberg, 2009; Bell, 2012). Several studies have so far been carried out to evaluate the impacts of tourism projects using different methods and models; for example, Ryan and Stewart (2009) examined the impacts of desert tourism in Dubai and concluded that desert tourism has positive impacts on the economic dimension within the area under the study. Bunruamkaew and Murayama (2011) identified and prioritized potential ecotourism locations using GIS and Analytic Hierarchy Process (AHP). They suggested landscape, naturalness, wildlife, community characteristics, and environmental compatibility as appropriate indicators of ecotourism site. In another study, Stylidis et al. (2014) adopted a three-line approach on the

impacts of tourism (economic, socio-cultural, and environmental) and examined the role of local residents in formulating their support for tourism development. In a study entitled, *Global Environmental Impact Assessment of Tourism*, Gössling and Peeters (2015) examined the impacts of rapid tourism growth and the use of global resources for sustainable tourism in the past, present, and future (2050-1900). Ashok et al. (2017) identified the common criteria and indicators associated with the evaluation of tourism and forest sustainability and used the Delphi method to analyze ecotourism sustainability at an operational level. To create an integrated decision-making method for tourist attractions and environmental protection, Tian et al. (2020) used the Environmental Impact Assessment (EIA) and Improved Analytic Hierarchical Process (AHP), which allowed them to evaluate tourist attractions for the effectiveness of the development approach in China. Employing the Delphi method for studying and determining the various dimensions of sustainable ecotourism in the deserts of Iran, Sepehr and Safarabadi (2014) identified and interpreted economic, social, and environmental indicators. They found that ecotourism can provide the socio-economic prosperity of desert communities and the protection of desert nature. Studies have also conducted to evaluate ecotourism as an ecological-social system utilizing the DPSIR model. Paziresh et al. (2013) used DPSIR framework and evaluated the changing and destructive factors of tourism in the rural areas of Vashi Strait. Using this framework, Tavakkoli-nia et al. (2018) evaluated the situation of ecotourism in Rudbar Qasran and Lavasanat regions. They concluded that the DPSIR structure serves as a decision support system for managers and planners in these areas and helps the application of appropriate solutions to the implementation of sustainable tourism. Moreover, Estalkhzir-Moradi, (2015) evaluated the economic impacts of tourism in Rezvanshahr in the field of rural ecotourism via DPSIR model.

The present study aimed to investigate and evaluate the environmental impacts of tourism development in the Lut desert using DPSIR and TOPSIS models. One significant feature that makes the current study different is the combination of the two above-mentioned models for the purpose of management strategies, which is expected to provide the opportunity for wisely tourism development based on the priority and importance of the impacts. In addition, since Lut desert is already on the World Heritage List, it is of great necessity to examine the foundations of tourism development in this sensitive ecosystem thoroughly while still at the early stages of development planning.

Materials and Methods

Study area (Lut desert)

Lut desert (E: 58°50'20" N: 30° 12' 58") has been registered as the first natural monument of Iran in the 40th UNESCO World Heritage Summit in 2016. This world heritage (Lut desert) is located across three provinces of Kerman, Sistan-Baluchestan, and South Khorasan (Figure 1). A variety of geographical terms, including desert, have been attributed to this vast natural phenomenon. Desert is an ecological and climatic term referring to a place barely covered with vegetation, and hardly inhabited by animals, with a dramatically low rate of rainfall; meanwhile, the Playa is called the lowest inland areas of the desert, where the amount of salt is very high. Desert is therefore a more comprehensive term to describe this natural phenomenon. The area of Lut desert is 22780 square kilometers large with a buffer zone of 17941 square kilometers. It is composed of two distinct regions in terms of topography ("Lut Desert World Heritage Website," 2019). The first is a vast and flat plain located in the center and the second is a complex of hills and separated highlands on the margins, which includes Yardangs (Kaluts), Yallan Sand Sea (Rig-e Yallan), Shur River, Gandom Beryan area, Nebkas, Hamadas, Rig-e Markazi (Central Erg), Shurgaz-e Hamun (Playa), and southern Erg. According to Figure 1,

Kaluts in the west and Rig-e Yalan in the east portray a picturesque and magnificent view. In general, the components of the Lut desert comprise Yardang in the western part, Rig-e Yalan in the eastern part, Hamada in the middle, and Nebka in the western part (Figure 1, source: Lut Desert World Heritage Website). This desert represents an interesting example of the integrated performance of geomorphic and geologic processes and climate changes. Together with its complex landforms, Lut desert is a part of the Lut plain, whose area is larger than the size of the property and its buffer zone. The existence of a set of spectacular desert landforms next to each other creates features that constitute the natural borders of the land. The entire land is bounded by these features from the east, west, north, and south. These features, as the main geomorphologic units of Lut desert, can readily be distinguished from the surrounding features (Maghsoudi and Talebian, 2015). In the morphotectonic divisions of Iran, the Lut hole is considered as a building block. This block is a low-lying area bounded on the east by the Khash-Nehbandan fault and on the west by the Nayband fault. In most cases, the diversity in forms of Kaluts is the result of the integrated interaction of water and winds. Nevertheless, not only is Lut desert aesthetically valued, but is also indicative of the historical processes involved in configuration of the region and of its geologic history. The diversity of landscapes and wilderness of the region provides an ideal site for scientific research and geotourism. In general, the Lut Basin is much larger than the Lut desert, which is considered a World Heritage Site (Lut Desert World Heritage Website, 2019).

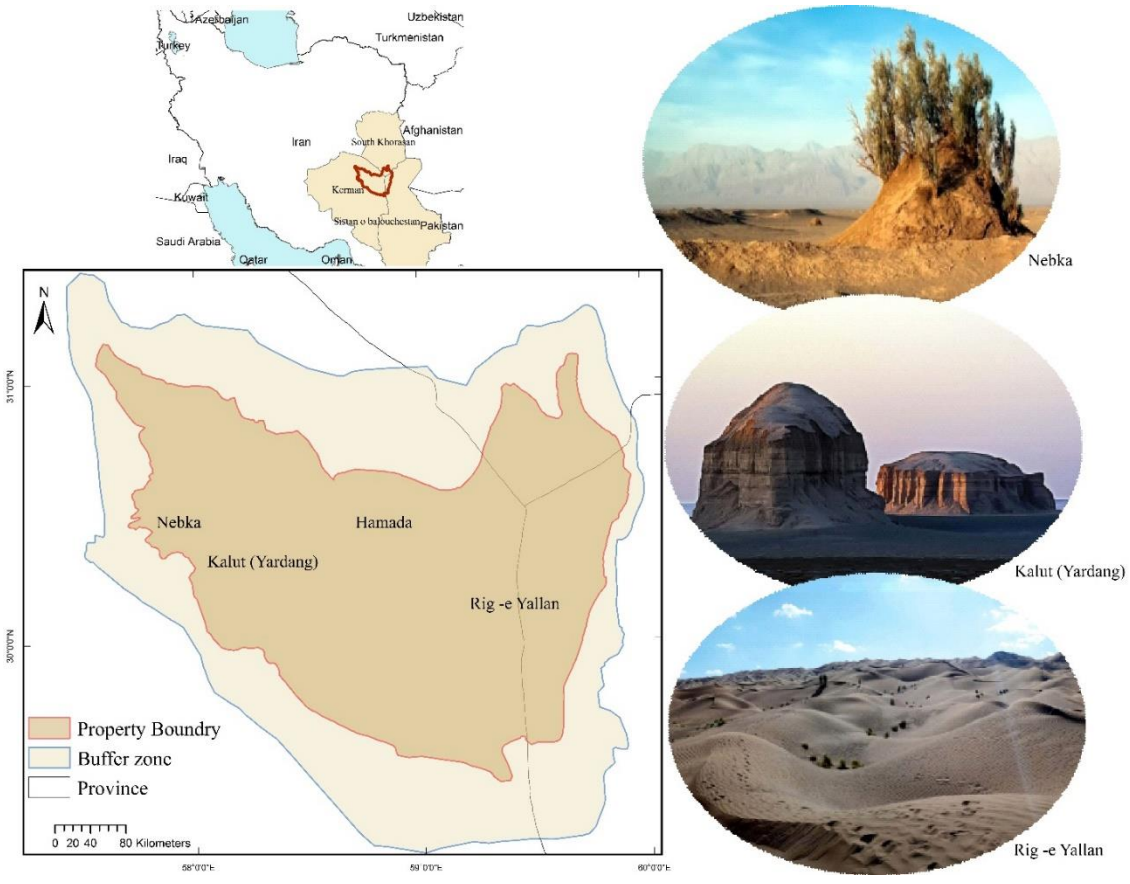

Figure 1. The Geographical location of Lut Desert and some nominated properties (The map produced by authors and pictures from Maghsoudi & Talebian, 2015)

Methodology

Conceptual DPSIR framework

A descriptive-analytical method was used in the present study. In order to determine the effective criteria on assessing the impacts of tourism development in the area under study, DPSIR method was employed. DPSIR is an efficient tool for explaining environmental issues and understanding the relationships between these issues (Lundin, 2003). This method was first used and widely applied by the European Environment Agency (EEA) (Smeets and Weterings, 1999). The DPSIR approach is an extended form of the PSR (Pressures, State, and Responses) framework developed by the Organization of Economic Co-operation and Development (OECD). This conceptual framework is applied for organizing environmental information and the relationship between human activities and possible environmental changes. This approach is based on a causal relationship, which begins with human activities (drivers) and pressures on the environment. It then leads to social responses resulting from quantitative and qualitative changes in natural resources. DPSIR analysis uses a set of indicators to provide specific and clear information to policy makers regarding the following cases (Zacharias *et al*., 2008): 1. drivers, 2. environmental pressures, 3. environmental status, 4. impacts of environmental changes, 5. possible social responses. The DPSIR framework and cycle are presented in Figure (2). The drivers are mainly socio-economic forces, recreational activities, and tourism infrastructure needs, which lead to either further environmental problems or exacerbating the existing problems. Pressures are human activities that directly destroy socio-economic impacts and the environment. The consequences of such pressures in a region have changed the conditions in the area under study (Tavakkoli-nia *et al*., 2018). Identifying the drivers' impacts is accompanied by feedback which takes the form of responses and strategies concerning the state of the environment. Responses are also activities carried out by human society with the aim of reducing environmental pressures and improving the quality of the environment, which finally result in optimal management at the regional level (Jahanishakib, Malekmohamadi, Zebardast, and Adeli, 2015). Responses are in fact the best way for drivers to reduce the pressures and impacts of dependent systems. However, they might be applied directly to each driver, pressure, state, or impacts (as shown in Figure 2, R1, R2, R3, R4).

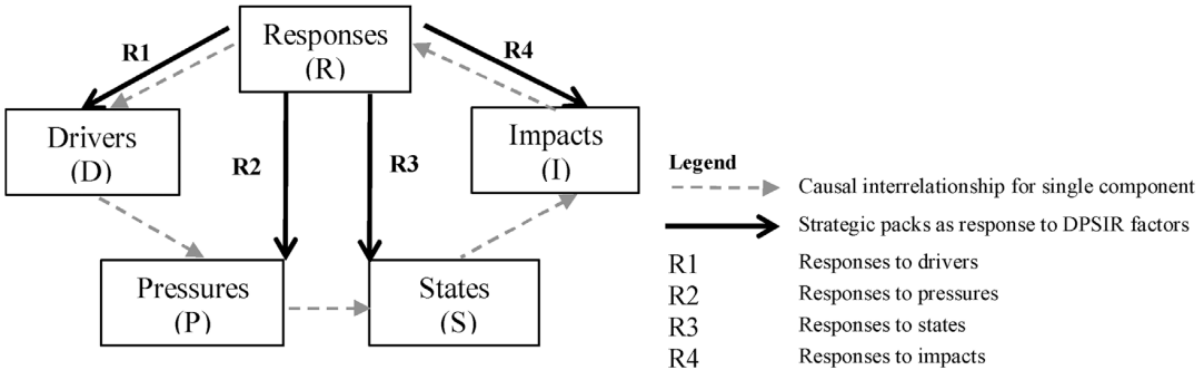

Figure 2. DPSIR framework and its components (Malekmohammadi & Jahanishakib, 2017)

Direct intervention at each stage may necessitate intervention at previous stages, which is impractical at the level of scientific knowledge or financial, technical or organizational constraints (Jahanishakib *et al*., 2015). It should be noted that economic and social developments (drivers) contribute to certain changes in the state of the environment (in physical, chemical, and biological properties). Additionally, these changes have impacts on

ecosystems, human health, and natural processes, which ultimately generate political responses (Smeets and Weterings, 1999). In the present study, the main threats in the region caused by tourism development were initially identified in the form of drivers using brainstorm. Afterwards, the pressures produced by each of the drivers in the environment (considered as the cause of problems) were identified and introduced. In the subsequent steps, the main causes of changes by the drivers were identified. Finally, the most effective outcomes due to the current conditions of the region were introduced.

TOPSIS technique

In the following stages, TOPSIS method and TOPSIS SOLVER software were used to rank and compare the influential criteria obtained from the previous steps on assessing the impacts of tourism development. This method is known as the *Technique for Order Preference by Similarity to Ideal Solution* (TOPSIS), and was first introduced by Wong and Yun in 1981. It is one of the multi-criteria decision-making methods. One of the advantages of this method is that the criteria or indicators used for the purpose of comparison can have different units of measurement and/or a negative and positive nature (Asgharpour, 2017). TOPSIS ranks the options to obtain the best alternative selection, which is the closest to the ideal solution. In other words, the best alternative has the farthest distant from the worst solution. The TOPSIS method takes into consideration the distance from both sides (Bulgurcu, 2012).
In this study, the Shannon entropy method was used to calculate the weight of criteria. The objective of the TOPSIS method was to rank the research options. The criteria were the effects identified in the previous step, which were collected through the expert opinions of 20 experts in the Likert scale (one to five). The entropy method adds more weight to the indices with greater variability. As a result, it is possible to differentiate between the units via the different weights that entropy produces. The entropy of each index (E_j) and the weight of the criteria (W_j) are obtained through the following steps (the weight of the criteria is the input of the TOPSIS method) (Asgharpour, 2017):
Step 1: we first form the decision matrix. To this end, if the criteria are qualitative, it would be adequate to evaluate each option against each criterion using the verbal expressions, and if the criteria are quantitative, the real number of that evaluation should be inserted. Equation 1 is a decision matrix in which the columns show the criteria and the rows show the options.

$$X = [X_{ij}]_{n\times m} = \begin{bmatrix} X_{11} & X_{12} & \cdots & X_{1m} \\ X_{21} & X_{22} & \cdots & X_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ X_{n1} & X_{n2} & \ldots & X_{nm} \end{bmatrix} \quad (1)$$

Step 2: the matrix above would be normalized and each normalized array is called p_{ij}. Normalization is the division of each column by the sum of the columns.
Step 3: The entropy of E_j is calculated as in Equation 2 and k is a constant value that holds the E_j value between 0 and 1.

$$E_j = -k \sum_{i=1}^{m} P_{ij} \times \text{Ln } P_{ij} \quad i = 1,2,\ldots,m \quad (2)$$

where p(x) is the probability distribution of the random variable X. An increase in Shannon entropy increases the level of uncertainty and decreases the amount of information about the random variable. Another aspect of Shannon entropy is its maximum entropy property for uniform distribution.
Step 4: the value of d_j (degree of deviation= 1- E_j) is calculated, which states the amount of the useful information provided for the decision-maker by the relevant index (d_j).The closer the

index values to each other, the less different the competing options would be with regard to that index. Therefore, the role of that indicator should be reduced in decision making equally.
Step 5: the weight of W_j is calculated via Equation 3. The weight of the criteria is equal to each d_j divided by the total number of d_js.

$$w_j = d_{j/\sum d_j} \quad (3)$$

The TOPSIS process begins to create the original data matrix using the criteria values achieved from entropy for each of the alternatives. TOPSIS transforms this original matrix into a normalized matrix; it incorporates five steps to determine the ranking of options (Bulgurcu, 2012).

Step 1. Normalization of alternative values

Normalization aims to maintain comparable scales. This paper used vector normalization, which utilizes the ratio of the original value (X_{ij}) and the square root of the sum of the original indicator values. This procedure is usually utilized in TOPSIS (Yurdakul and Ic, 2003). Equation 4 is as follows:

$$r_{ij} = \frac{X_{ij}}{\sqrt{\sum_{i=1}^{m} X_{ij}^2}} \quad (4)$$

where *i* is the *i*th option, *j* the *j*th evaluation indicator, r_{ij} the indicator value after vector normalization for the *i*th impacts and *j*th evaluation indicator, X_{ij} the original value of indicators for the *i*th impacts and *j*th evaluation indicator, and *m* the number of impacts.

Step 2. Determination of ideal (A^+) and negative ideal (A^-) solution

$$A^+ = \{(max_i\, r_y \mid j \in J\ ), (min_i\, r_y \mid j \in J) \mid i = 1,2,\dots,m\} = \{A_1^+, A_2^+, \dots, A_j^+, \dots, A_k^+\}$$
$$A^- = \{(min_i\, r_y \mid j \in J\ ), (max_i\, r_y \mid j \in J) \mid i = 1,2,\dots,m\} = \{A_1^-, A_2^-, \dots, A_j^-, \dots, A_k^-\} \quad (5)$$

J= {*j*=1, 2,..., k| k belongs to benefit criteria}benefit criterion implies a larger indicator value and a higher performance score. *J'*= {*j*=1, 2,...,k | k belongs to cost criteria/criterion} cost criterion implies a smaller indicator value and a higher performance score.

Step 3. Calculation of the separation measure

The separation of each option from the ideal one (S_i^+) and the worst one (S_i^-) is then respectively given by

$$S_i^+ = \sqrt{\sum_{j=1}^{k}(r_y - A_j^+)^2}\ \ S_i^- = \sqrt{\sum_{j=1}^{k}(r_y - A_j^-)^2}\quad i = 1,2,\dots,m \quad (6)$$

Step 4. Calculation of the relative closeness to the ideal solution (C^*)

$$C_i^* = \frac{S_i^-}{S_i^- + S_i^+}\quad 0 < C_i^* < 1 \quad (7)$$

Step 5. Ranking the preference order according to the descending order of C_i^*

Finally, after evaluating the environmental impacts of desert tourism development, possible answers are provided in the form of management solutions, which can be considered as a step toward reducing the impacts and enabling the optimal management of environmental conditions. The responses mostly cover the policy and application of restrictions (Tavakkolinia *et al*., 2018).

Results and Discussion

The most important driving forces or threatening factors of tourism development were classified in two categories: tourism activities and the infrastructure needs of tourists. The potential and actual tourism activities were identified in Lut desert, including sports tourism, medical tourism, sightseeing for wildlife and endemic species, visiting cultural and educational heritage, and exploring unique landscapes, such as Nebkas, Rig-e-Yalan, and Kaluts. Regarding the infrastructure needs of tourists in the course of tourism development, certain factors such as amenities (shelter, water, fuel, and food), transportation facilities (road, rail, and air), and tourism equipment (guide, proper car, and GPS) were identified. Subsequently, the pressures and consequences of each driving force were introduced. Out of the most important cases of the changes caused by the driving force of tourism activities, one can mention attitudinal changes of indigenous people towards their own culture, changes in the desirability and quality of habitat, increase in the waste production rate, and increase in income and job opportunities. Furthermore, due to the pressures imposed by the development of infrastructure needed for tourism in Lut desert, a predictable situation can be illustrated: improvement in the infrastructure services and the quality of roads, reduction in poverty among residents, changes in the motivation and participation of local residents, increase in excavation and leveling operations, and changes in prices, consumption, and non-consumption costs (Table 1). The category of the predictable impacts also includes decline in vegetation, arid-lands species, and the wildlife richness, enhanced stress and disruption in natural wildlife behavior, damage to fragile desert ecosystems, increase in economic prosperity, and decrease in visual quality due to piles of garbage, reverse migration from the city to the countryside, and improvement and restoration of desert structures. Due to the nature of tourism development and the principles adopted in promoting tourism culture, some impacts can have different dimensions and different consequences. In the present study, these impacts were presented as a separate section entitled Dual Issues, such as the increase in the sense of belonging and pride in the native residents and adherence to local customs and traditions. In the following step, using the TOPSIS method, each impact was prioritized to positive and negative ideals based on the proximity coefficient (Table 2). The results obtained from the conceptual model of DPSIR and TOPSIS technique revealed that the development of tourism leaves a combination of negative and positive impacts on the area under study. The weight of each indicator was calculated according to the entropy method and the weighted normalized matrix was determined after weighting according to Table 2. Application of TOPSIS analysis showed that the distances between different impacts were ranked according to the coefficient of data proximity as shown in Table 3. Moreover, the first to fifth priorities were recognized to be important according to the experts' opinions: the fading or disappearance of culture and customs, creation of cultural and social dualities, changes and destruction of land uses for infrastructure development, activate diplomacy, and the reduction in political conflicts. The results indicated that the economic consequences are mostly positive although the environmental and social consequences have negative impacts rather than positive ones on the tourism in this region. Social and cultural criteria are influenced by to the development of tourism. The culture of the visiting tourist, which is different from the target culture, might cause a series of tensions leading to a change in the pattern and lifestyle of the host community. Indices of increased awareness of the values of the region and participation in its preservation, reduced vegetation and arid land species, and the improved quality of infrastructure and profitability in the hotel and restaurant sector were also found to have decreased, which had a negative effect on tourism.

Table 1. Applying the DPSIR model to socio-ecologic systems of Lut desert tourism development

	Drivers	Pressures	States	Impacts	Responses
Tourism activities	• Sports tourism (walking, cycling, motorcycling, Board riding, car driving and off-roading on dunes) • Medical tourism (sun therapy, sunbathing, sand therapy) • Patrol to observe wildlife and species • Visiting cultural and educational heritage (aqueduct or Qanat, Cistern or Ab-anbar, windmill or Asbad, handicrafts shopping, star observation) • Visiting novel landscapes (dunes, Rig-e-yallan, kaluts)	• Expand vehicle traffic • Leveling and sharpening access routes • Visitor population density in tourism seasons • Noise pollution caused by motor vehicles • Production of wastewater and waste • Prosperity and improvement of local handicrafts and products • Development of formal and informal relations at national and international levels • Increasing the indigenous population due to economic prosperity	• Changes in vegetation and biodiversity • Change in soil granulation • Increase waste entry • Changes in the desirability and habitat quality • Increase income and job opportunities • Attitudinal changes of the indigenous people towards their own culture • Increase the attention of officials to the region • Increase of various pollutions such as (water, sound, soil, etc.)	• Decreased vegetation and arid land species • Reduction of animal species richness • Creating stress and disrupting the natural behavior of wildlife • Damage to fragile ecosystems • Increasing economic prosperity • Decreased visual quality due to waste entry • Reverse migration from city to village • Improvement and restoration of desert structures (Asbad, Ab-Anbar, Qanat) **Dual issues:** - Increase in the sense of belonging and pride in the native residents - Adherence to local customs and traditions - Loss of culture and customs - Creating cultural and social dualities	After prioritizing the impacts using TOPSIS method, the answers will be provided to control the environmental impacts
Infrastructure needs of tourists	• Amenities (shelter, water, energy and food) • Transportation facilities (road, Rail lines, air lines) • Tourist equipment (tour guide, suitable car and GPS)	• Extensive use of more durable materials in construction • Development of agricultural and livestock activities • Land use change • Development of water resources • Development of ecotourism hotels, restaurants and resorts • Development of airports and freeways • Human resource development (tour guide, cameleer, off-road driver)	• Improving infrastructure services • Improving the quality roads • Changing the quality of internal and external pass ways in the region • Reduce poverty among indigenous peoples • Change in the level of natives motivation and participation • Increase excavation and leveling operations • Changes in prices and consumption and non-consumption costs	• Increase awareness of the values of the region and greater participation in protection • Activation of system diplomacy • Reducing political conflicts • Prosperity and improvement of infrastructure quality • Increase costs in tourism seasons • Profitability in the hotel and restaurant sector • Changing and destroying land uses to develop infrastructure	

Table 2. Determining the weight of indices based on entropy method

	Options	Very low impact	Low impact	Medium impact	high impact	Too much impact
1	Decreased vegetation and arid land species	0.0093	0.0049	0.0038	0.0100	0
2	Decreased animal species richness	0.0037	0.0053	0.0077	0.0200	0
3	Creating stress and disrupting the natural behavior of wildlife	0.0056	0.0049	0.0077	0.0200	0
4	Damage to fragile ecosystems	0.0074	0.0045	0.0077	0.0200	0
5	Increasing economic prosperity	0.0241	0.0026	0	0	0
6	Decreased visual quality due to waste entry	0.0093	0.0030	0.0115	0.0400	0
7	Reverse migration from town to village	0.0129	0.0030	0.0115	0.0200	0
8	Improvement and restoration of desert structures (Asbad, Ab-anbar, Qanat)	0.0111	0.0034	0.0191	0	0
9	Increase in the sense of belonging and pride in the native residents	0.0186	0.0026	0.0077	0.0100	0
10	Encourage adherence to local customs	0.0129	0.0034	0.0077	0.0200	0
11	The fading or disappearance of culture and customs	0.0037	0.0015	0.0191	0.0801	0.7021
12	Creating cultural and social dualities	0	0.0023	0.0229	0.0801	0
13	Increase awareness of the region's values and greater participation in its preservation	0.0111	0.0042	0.0115	0	0
14	activation the government diplomacy	0.0037	0.0011	0.0536	0.0100	0
15	Reducing political conflicts	0.0037	0.0023	0.0421	0.0100	0
16	Prosperity and improvement of infrastructure quality	0.0129	0.0045	0.0038	0	0
17	Increasing costs in tourism seasons	0.0074	0.0026	0.0306	0.0100	0
18	Profitability in the hotel and restaurant sector	0.0111	0.0049	0.0038	0	0
19	Modification and destruction of land uses for infrastructure development	0.0056	0.0030	0.0077	0.0701	0

The results showed that the development of tourism in the region is accompanied with infrastructural and physical changes. There are also tensions in the environment for building the necessary infrastructure, but it is critical to manage these tensions using the right measures for tourism development in Lut desert. In order to properly manage and direct the path of sustainable tourism development, and in response to the highly significant impacts, some strategies were suggested in the current study to mitigate the effects:

1. Creating a culture and providing general and specialized educational opportunities to the tourist community;
2. Educating the host community of tourism and endemic people;
3. Respecting the indigenous culture of the people and the cultural position of the region;
4. Proper planning and management of land use to develop infrastructure;
5. Investing in pollution management, planning, and monitoring;
6. Improving the culture of waste segregation;
7. Improving and restoring the damaged ecosystems;
8. Investing in cost control and management;
9. Protecting natural resources, biodiversity, and development of ecotourism resorts;
10. Enabling public participation in natural resource management;
11. Increasing environmental awareness and environmental protection by natives and tourists.

The efficiency of the DPSIR method in tourism management was confirmed by the study of Tavakkoli-nia *et al*. (2018). The results of the present study are in line with those obtained by Sepehr and Safarabadi (2014). They also concluded that ecotourism leaves a combination of positive and negative impacts on the host community and its natural heritage. Certain factors, including greater participation in its preservation of the region, increasing environmental awareness, sense of belonging to indigenous people, and increasing economic prosperity, explain the most positive impacts of the changes related to the consequences of ecotourism on desert areas. Therefore, it could be expected that ecotourism provide the opportunity for the socio-economic prosperity of desert communities and the protection of desert nature. The

findings of Amirhajlou et al. (2013) were also in agreement with the results of the present study concerning the positive and stimulating impact of tourism on job creation and income generation of local communities. They also confirmed the impact of this region on the development of ecological tourism while improving regional planning to preserve natural resources and reduce negative impacts.

Table 3. Ranking the indices based on distance of the positive and negative ideal solution TOPSIS SOLVER

	Options	Positive ideal solution (A^+)	Negative ideal solution (A^-)	Relative closeness to the ideal solution (C*)	Priority (Rank)
1	Decreased vegetation and arid land species	5.622993	0.603034	0.09686	17
2	Decreased animal species richness	5.50625	0.807445	0.12789	15
3	Creating stress and disrupting the natural behavior of wildlife	5.503482	0.781445	0.12434	12
4	Damage to fragile ecosystems	5.501422	0.759704	0.12134	11
5	Increasing economic prosperity	5.761741	0.549081	0.08701	10
6	Decreased visual quality due to waste entry	5.333735	1.1947707	0.183	6
7	Reverse migration from town to village	5.465608	0.764258	0.12268	8
8	Improvement and restoration of desert structures (Asbad, Ab-anbar, Qanat)	5.588517	0.75652	0.11923	14
9	Increase in the sense of belonging and pride in the native residents	5.586818	0.579801	0.09402	13
10	Encourage adherence to local customs	5.499496	0.723498	0.11626	9
11	The fading or disappearance of culture and customs	1.349894	5.489781	0.80264	1
12	Creating cultural and social dualities	5.149693	2.310883	0.30975	2
13	Increase awareness of the region's values and greater participation in its preservation	5.646687	0.601189	0.09622	16
14	activation the government diplomacy	5.391515	1.86157	0.25666	4
15	Reducing political conflicts	5.393568	1.480172	0.21534	5
16	Prosperity and improvement of infrastructure quality	5.716838	0.532269	0.08518	18
17	Increasing costs in tourism seasons	5.427651	1.114176	0.17032	7
18	Profitability in the hotel and restaurant sector	5.718001	0.554475	0.0884	19
19	Modification and destruction of land uses for infrastructure development	5.272701	1.933383	0.2683	3

Conclusions

Lut desert is a legacy of geological and natural monuments of different periods, which, if the socio-economic and ecological potentials allow, will undoubtedly be promising for the sustainable development of these areas. The current study aimed to assess the environmental impacts of tourism development. The DPSIR analytical framework was used studying Lut desert. Expert opinions were collected through a questionnaire and the importance of each effective driver was measured via the TOPSIS method. The formulation of tourism impact management strategies is possible by integrating the two above-mentioned models, which is believed to be one of the efficiencies of this approach. The influential factors and different aspects of tourism development in Lut desert were identified and extracted according to the results of the analyses conducted in each section. Ultimately, to reduce the impacts and manage the conditions, certain management strategy-associated solutions were introduced. The results implied that the expansion of tourism in the region has positive and negative impacts and consequences. According to the research findings, tourism can have a positive potential to increase the economic prosperity. At the social and cultural level, in view of the nature of tourism development and the principles used in promoting tourism culture, the impacts can

have different dimensions, such as increasing the sense of belonging and pride in the natives, adherence to customs and traditions, or destruction of culture and customs, creation of cultural and social dualities, increasing awareness of the values of the region, and greater participation in its protection. The most negative impact of tourism is related to the natural environment sector. Decreased visual quality as a result of larger amounts of waste, degradation and destruction of fragile ecosystems, vegetation loss, land use change, and landscape degradation without proper planning can all have adverse effects on the natural environment of Lut desert. Therefore, the expansion of tourism without proper planning and management is undoubtedly a threat to the integrity of the ecosystem and culture in this region. Thus, the development of tourism in the region requires the implementation of well-established policies and regional planning, as well as paying attention to the protection of natural resources and reducing the negative impacts. The set of solutions presented in the current research could be considered by relevant organizations in tourism planning and management.

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